Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 4 (2015) 115 – 123

Procedia MANUFACTURING

Industrial Engineering and Service Science 2015, IESS 2015

A system analysis and design for packaging design of powder shaped fresheners based on *Kansei* engineering

Taufik Djatna[a*], Wenny Dwi Kurniati[b]

[a]*Postgraduate Program of AgroIndustrial Technology, Bogor Agricultural University, Bogor 16680, Indonesia,*
[b]*Graduate Program of Agro Industrial Technology, Bogor Agricultural University, Bogor 16680, Indonesia*

Abstract

Natural fresheners such as tea, coffee and chocolate that stimulate the nerve response to more active resulting in fresher effect for the user. Most of tea are processed as powder shaped. Currently tea powder still used the traditional packaging which incompetence with international competitor. To support customer preferences and to improve sales of tea powder product, the packaging design must be attractive. Main contribution of this research were to identify the design element of packaging design, identify packaging design on Kansei words and formulate the new packaging design. Kansei Engineering were useful in creating a new invented product in order to bridge the desired product characteristics for consumer's perception. The process modelling phase for system analysis and design starts from Business Process Model and Notation (BPMN) to get the improvement of packaging functionality, usability and pleasurable. Data and information were acquired by questionnaires. The methods of Kansei words with TF-IDF, and formulation of packaging design with QTT1 approach. The result of this research show that the formulation of new packaging design with eye catching strategy, make the color is green, the image is cup, the typography is custom and the shape is attractive.

Peer review under responsibility of the organizing committee of the Industrial Engineering and Service Science 2015 (IESS 2015)

Keywords: Kansei engineering, packaging design, QTT1, system analysis and design, TF-IDF

* Corresponding author. Tel.: +62-813-1972-6435; fax: +62-251-862-2313.
E-mail address: taufikdjatna@ipb.ac.id

Peer review under responsibility of the organizing committee of the Industrial Engineering and Service Science 2015 (IESS 2015)
doi:10.1016/j.promfg.2015.11.021

1. Introduction

Customizable designs discriminate competitiveness between companies, enhancing the quality and penetrating customer perception with better and unique products. The problem faced by designer is how to match their product by developing preferred product for generic user or the specific customers' perception. It is an opportunity to make improvements in terms of the appearance of packaging design and packaging quality, thus indirectly will result in increased preference, pleasure and satisfaction of consumers. Nowadays, consumers are stricter to choose the products in terms of demand, needs, and preferences. Development product is a process in company to produce the output products are attractive and favored by customers. Emotions feelings, creativity and innovative aspect are key to improve customer acceptance of products [1].

Packaging design be said to have a starting role that consumers must be passed in the decision to purchase a product. To be able to influence the consumer's decision required a packaging design that is attractive and unique. The design should be able to touch the emotional side of the consumer. Emotional experience in the packaging is produced from seeing or touching the container [2]. Having regard to the emotional side of the consumer to be produced packaging that may affect the interest of potential buyers to purchase the product. One of the methods used to design the packaging of this is to use the *Kansei* engineering.

Kansei engineering is defined as a technology that translates for costumer's *Kansei* (psychological feeling) into design specifications [3]. *Kansei* engineering is sometime useful in creating a new invented product. Developing design products through their own concepts. While consumers want their products in accordance with the design feeling, function and price of the consumer.

The exploration of *Kansei* words to beverage packaging design actually is not easy to define, although the data sets get from customer / user respond. After the data construct in form decision tables, the next problem is vagueness to clearly define specific relation for conditional attributes and decision attribute. Beverage packaging design is a unique one because in packaging should consider elements attribute with any information about product and other have functionality as protection [4].This is a new example of application of *Kansei* engineering in packaging design of powder shaped freshener. There were three main objectives in this research as follows: (1) identification the design elements of packaging design, (2) identification packaging design on *Kansei w*ords and (3) formulate the new packaging design. In the future be required quantitative and qualitative formulation for adaptive model of packaging design of powder shaped fresheners.

This paper is constructed as follows the related works for analysis and packaging design system based on KE in Section 2, the described of methodology in Section 3. Section 4 present the result and discussion for application example of proposed method to tea powder packaging design. In section 5, main conclusion are covered.

2. Related works

System is an integrated set of interoperable elements that working synergistically to perform value-added processing and to satisfy the user with a specified outcome [5]. Every system consists of its inputs, entities, outputs, stakeholders, roles, constrains, etc. that need to be identified. The components that construct system entity are presented in Fig. 1.

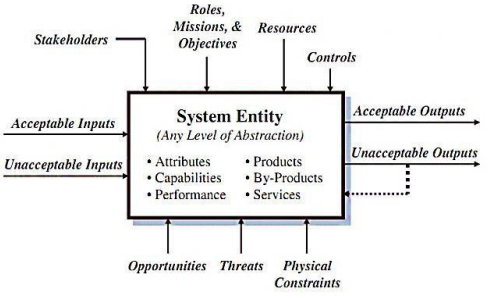

Fig. 1. System entity construction (Wasson 2006)

Kansei Engineering (KE) is a technology that translates the *Kansei*, or images, that consumers have in their minds regarding product designs. Hybrid *Kansei* Engineering is a type of KE System (KES) by Forward KES and Backward KES to form Hybrid KES. This type of KE enables iterative process from design element to *Kansei* evaluation. Hybrid KE implementation can be seen in the study of high heel design [6] and in the work of [7].Method of *Kansei* Engineering is a method used to identify the psychological aspects of consumers when interacting with products and find the relationship between the feeling and the products [8]. In practice, this method has the characteristic form of words which symbolizes the desire of consumers to the product, which is called *Kansei* words. The *Kansei* words into the variables that will be taken into consideration in designing new packaging design.

There are has three types of information designers need to capture the visual system, namely packaging design, descriptions and relationships [9]. Stated in packaging design challenge is whether the characteristic attribute- design element that is able to attract the attention of consumer, and whether packaging is able to perform the function in accordance with its properties[4]. The challenges in the packaging industry show designers generate strongly about it and visualize the product in the form of simple and effective, leaving a positive perception to the consumer or buy other among similar products [10]. The properties of the packaging material and affective perception influence consumer decisions such as hardness, abrasive, softness, smoothness and warm [6] and [10]. There are no effect the form of packaging to the consumer purchasing preferences [11]. The design elements are divided into structural packaging design and graphic surface, again in the top of the form and function, material and completion, branding and typography, image and color [10]. The basic idea is the packaging design set of layers (silos), where each layer has several alternative options (elements) and the state that attribute form elements such as logo design, nutrition and health statement, style (style), picture (image), aroma (flavor) and color [4]. A study of traditional Chinese design food packaging (moon cake) with a focus on elements of text, graphics, color and layout [12]. The visual elements of packaging design is the word, graphics, colors, trademarks, shape, size, texture [13]. Research for wine packaging with design elements, label and typography [14].

3. Methods

3.1. Requirement analysis and system modelling

Process requirement analysis defined as first stage assessment in system approach and require to develop a system properness. The aim's in this stage is to define factors in analysis system in overall stakeholder. In this topic, a system or subsystem as it exist within the cooperate stakeholder may be graphically model which show the boundary system and the information used in the system. With analysis and design, the production system that can improve the efficiency and effectiveness in the system especially in order to produce the packaging design of tea powder by using the *Kansei* engineering method was produced. Analysis and business modelling using BPMN workflow using software such as Sybase Power Designer 16.0 (SAP, 2013). In BPMN processes and sub processes analysis performed in the study in order to obtain an overall process flow.

3.2. Packaging design element identification

Identification of product design is the initial phase to develop the product design. In this paper, we identify the design of tea powder product in order to understand the design elements of tea powder product with collecting samples of tea powder product.

3.3. Packaging design element on Kansei words

In this paper determined the attributes of packaging design based on *Kansei* words in order to obtain correct to design the packaging especially for tea powder. The *Kansei* words were derived from the collecting in some books, journal, internet, etc. Then the KW was extracted and grouping them by using TF-IDF method that is one of the methods of text mining. From this, representative KW were finally chosen and become the strategies of design product based on KW which is answer the first objective in this paper.

TF-IDF stands for term frequency–inverse document frequency, is a statistic method that is intended to reflect how important a word is to a document in a collection. It is a way to score the importance of words (or "terms") in a KW based on how frequently they appear across multiple questionnaires. The following (1) common variant was used in our experiments:

$$w_d = f_{w,} \times log\ (\ |D| / f_{w,D}) \quad (1)$$

Where wd is the weight of the TF-IDF, fw, is the frequency of word w in document d, and D is the number of documents in the text collection. Normalization to unit length is generally applied to the resulting vectors.

3.4. Packaging design formulation

Formulation of tea powder packaging design based on KE is obtained as a result of the interaction between product design strategies and design product elements. Once more questionnaire were giving to consumers to evaluate product properties based on strategy product that would have determined before. Semantic differential scales (7 scales) were used here. Scale with the two extremes ranges “not at all” to “very much”.

The result of the evaluation were synthesized by using quantification theory type 1 (QTT1) method. By using this method, would get the formulation of packaging design of tea powder and it would answered the second objective of this paper. The QTT1 can be regarded as a method of quantitative and categorical multiple regression analysis method, which allows inclusion of independent variables that are categorical and qualitative in nature. The QTT1 consist of the followings six steps (Lin et al. 2012):

Step1: define the *Kansei* relational model associated with the *Kansei* measurement score of experimental sample with respect to an image word pair. The categorical multiple regression model can be defined as (3):

$$\hat{y}_s^k = \sum_{i=1}^{E} \sum_{j=1}^{c_i} \beta_{ij} x_{ijs} + \varepsilon \quad (2)$$

$\hat{y}_s^k$ = the predicted value of criterion variable for the s^{th} product sample on the k^{th} image word.
i = the index of design element
E = the number of design element
j = the index of category
C_i = the number of category of the i^{th} design element
ε = a stochastic variable whose expectation value E (ε)=0
β_{ij} = the category score of the j^{th} style within the i^{th} design element
x_{ijs} = the coefficient of the dummy variable

Step 2: calculate the standardized regression coefficients (4) and standardized constant in model (5). The model of categorical multiple regression analysis can be redefined as (3):

$$\hat{y}_s^k = \sum_{i=1}^{E} \sum_{j=1}^{c_i} \beta_{ij}^* x_{ijs} + \bar{y}_s^k \quad (3)$$

$$\beta_{ij}^* = \beta_{ij} - \frac{1}{n} \sum_{j=1}^{c_i} \beta_{ij}^* x_{ijs} \quad (4)$$

$$\bar{y}_s^k = \frac{1}{n} \sum_{j=1}^{c_i} y_s^k \quad (5)$$

Step 3: Determine the matrix CCR of correlation coefficient of all variables.

Step 4: Calculate the multiple correlation coefficient (R) that is regarded as the relational degree of external criterion variable and explanatory variables. Step 5: Calculate the partial correlation coefficients (PCC) of design elements to clarify the relationships between product element and a product image. Step 6: Determine the statistical range of categorical variable which indicates its contribution degree to the prediction model with respect to a given product

image.

4. Result and Discussion

4.1. Requirement Analysis and System Modelling

To analyze and to design production system by using *Kansei* engineering on tea powder with to identify of all things that needed in whole system was begin. The system have three stakeholders, there are packaging manager, designer, and R&D manager, there are presented in Fig. 2.

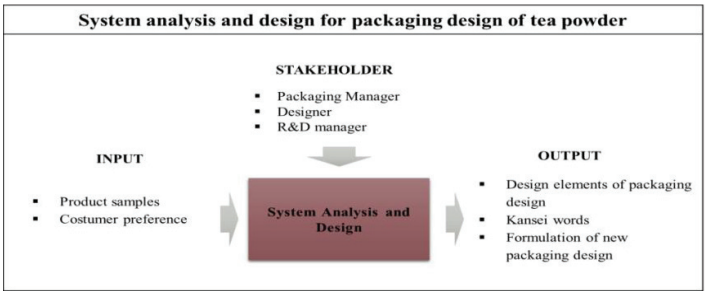

Fig. 2. System analysis and design for packaging design of tea powder

Finally the Business Process Modelling and Notation (BPMN) that represent all detailed relationship between process, sub process, workflow, stakeholder, and formulation that involved in the system was build. BPMN for the identifying packaging design element, determining packaging design strategies with *Kansei* words and formulating product design is presented in Fig. 3, 4 and 5.

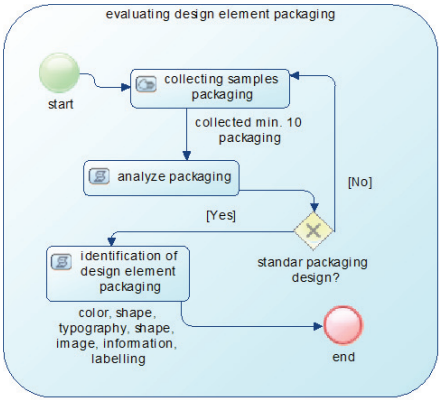

Fig. 3. BPMN for identifying of design element packaging

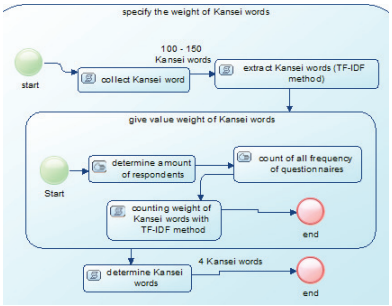

Fig. 4. BPMN for determining packaging design on *Kansei* words

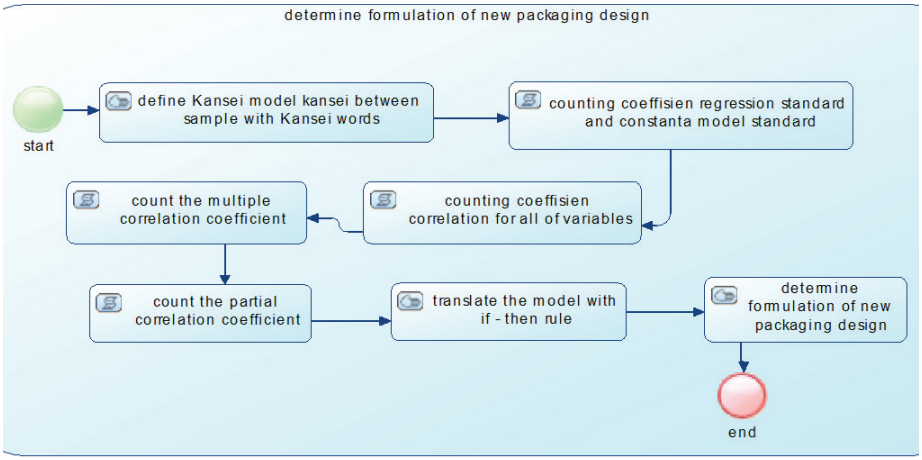

Fig. 5. A BPMN for formulating packaging design with QTT 1

4.2. Packaging design element identification

Identify the packaging design of tea powder by collecting 10 tea powder products. The identification of tea powder products is presented in Table 1.

Table 1. Identification of packaging design tea powder

Design element	Type			
	1	2	3	4
Color	Red	Yellow	Green	Blue
Image	Cup	Leaf Tea	-	-
Typography	Custom	Standard	-	-
Shape	Attractive	Slim	Robust	-

After identify the design element of product, then classify them into their design elements. The result of the classification is presented in Table 2.

Table 2. Classification of packaging design element

No samples	X1	X2	X3	X4
1	1	2	2	2
2	2	1	1	2
3	3	2	2	2
4	2	1	1	1
5	4	1	2	3
6	1	2	2	3
7	3	1	2	3
8	2	1	2	2
9	1	2	1	2
10	1	1	2	3

4.3. Packaging design element on Kansei words

The formulation use TF-IDF method on *Kansei* words analysis. Collected 20 questionnaires about *Kansei* words from consumers. In Table 3, there are the results of calculation *Kansei* words by using TF-IDF from a hypothetical data of the questioner. The result is showing that the *Kansei* words that have the highest weight is “bright”, “modern”, “simple”, “eye catching”. From this result, the strategies for developing the packaging design of tea powder product was determined. Then this result were used for synthesis phase to get the formulation of packaging design of tea powder product.

Table 3. The result of calculation KW from questionnaires by using TF-IDF

Kansei words	1	2	3	4	5	6	….	20	W_d
Bright	0	0	1	0	1	0	…	1	**3.184**
Beautiful	0	1	1	1	0	0	…	1	2.856
Strange	1	0	0	1	0	1	…	1	3.013
Unique	1	0	1	1	1	0	…	0	2.432
Colorful	1	1	0	0	1	0	…	0	3.121
Interesting	1	0	0	0	1	0	…	0	3.010
Elegant	0	0	1	1	0	1	…	1	2.856
Trendy	1	0	1	0	1	0	…	1	3.121
Modern	1	1	0	0	0	1	…	0	**3.183**
Simple	0	0	1	0	1	0	…	1	**3.191**
Look different	1	0	0	0	0	1	…	1	2.662
Eye catching	1	0	0	1	0	1	…	1	**3.184**

4.4. Packaging design formulation

Collecting the questionnaires for evaluate the existing samples product with design product strategies. These questionnaires involve 10 samples product and 20 respondents. The result of hypothetical data of this questioner is represented in Table 4. B-D is bright and dull, MD – TRD is modern and traditional, the S-C is simple and complex, then EC-US is eye catching and unsightly. Software R were deployed on QTT1 analysis to examine the relationship between the four product form elements and four product images.

Table 4. Evaluating samples packaging design

No samples	X1	X2	X3	X4	Bright – Dull	Modern - Traditional	Simple - Complex	Eye catching - Unsightly
1	1	2	2	2	4.30	4.60	4.25	4.35
2	2	1	1	2	4.15	3.75	3.65	4.75
3	3	2	2	2	4.50	3.50	3.50	4.65
4	2	1	1	1	4.10	4.25	4.05	4.90
5	4	1	2	3	3.75	4.05	3.35	3.65
6	1	2	2	3	3.35	4.50	3.55	4.00
7	3	1	2	3	3.70	4.80	4.40	4.50
8	2	1	2	2	3.95	3.45	4.95	3.75
9	1	2	1	2	2.95	4.55	4.45	4.85
10	1	1	2	3	4.40	4.40	4.00	4.00

The QTT-1 analysis method computation was generated by using programming in R language and the result was represented in Table 5. From the Table 5 will know instantly the recommendation of developing the combination packaging design on tea powder product. The values in each category show the influence level of tea powder packaging design product. The highest positive value of category score in R^2 was recommended. The design support information of the new packaging design of tea powder is represented in Table 6. By implementing this system, the tea powder packaging design formulation was developed.

Table 5. The result of QTT1 analysis

Design element		B – D		MD – TRD		S – C		EC – US	
		Category score	PCC	Category score	PCC	Category score	PCC	Category score	PCC
X1	X11	0.169	0.315	0.462	0.774	0.399	0.603	0.053	0.950
	X12	-0.284		-0.601		-0.304		-0.307	
	X13	0.156		0.109		-0.014		0.513	
	X14	-0.137		-0.264		-0.657		-0.317	
X2	X21	0.283	0.522	0.111	0.336	0.343	0.627	0.008	0.106
	X22	-0.424		-0.166		-0.514		-0.012	
X3	X31	-0.523	0.630	0.219	0.480	-0.243	0.354	0.532	0.954
	X32	0.224		-0.094		0.104		-0.228	
X4	X41	0.709	0.645	0.336	0.525	0.239	0.632	0.327	0.807
	X42	0.286		-0.157		0.316		0.057	
	X43	-0.534		0.112		-0.454		-0.153	
Constant		3.915		4.185		4.015		4.340	
R		0.716		0.852		0.701		0.983	
R^2		0.513		0.726		0.491		0.967	

Table 6. Design support information for the new packaging design of tea powder

Design element	X1	X2	X3	X4
	Color	Image	Typography	Shape
Bright	Blue	Cup	Custom	Attractive
Dull	Yellow	Leaf tea	Standard	Robust
Modern	Red	Cup	Custom	Attractive
Traditional	Yellow	Leaf tea	Standard	Slim
Simple	Red	Cup	Standard	Slim
Complex	Blue	Leaf tea	Custom	Robust
Eye catching	Green	Cup	Custom	Attractive
Unsightly	Blue	Leaf tea	Standard	Robust

5. Conclusion and recommendation

The results of this research show the system consists of three stakeholders there are packaging manager, designer, and R&D manager. The identification of tea powder packaging design, consisted of four design element there are color, image, typography and shape. The design of tea powder packaging design on *Kansei* words fall into four categories of bright, modern, simple, and eye catching. Finally, the formulation of new packaging design of tea powder obtained using KE in which tea powder packaging design with eye catching strategy has the highest R^2 so that fitted to statistical model, very important and recommended. In order to realize this design in green color, cup-shaped, with customized typography. In the future be required quantitative and qualitative for adaptive model of packaging design of powder shaped fresheners others.

References

[1] J.R. Jiao, Y Zhang, M Helander, A *Kansei* Mining System for Affective Design. Expert Systems with Applications 30, 2006, 658 – 673.
[2] P.M.A. Desmet, "*Designing Emotion*". *International Journal of Design*, 2002
[3] M. Nagamachi, Perspectives and new trend of *Kansei*/Affective Engineering. TQM Journal, 2008.

[4] H.R. Moskowitz, M. Reisner, KawlorJb, R. Deliza, PackagingResearch in Food Product Design and Development, Wiley-Blackwell, 2009.
[5] C.S. Wasson , *System Analysis, Design, and Development: Concepts, Principles and Practices*. Canada: John Wiley & Sons, inc, 2006.
[6] J. Chen, K. Wang, J. Liang, A Hybrid *Kansei* Design Expert System Using Artificial Intelligence. Ho. T., Zhou, Z. (Eds.). PRICAI 2008. LNAI 5351, 2008, pp. 971-976.
[7] Y. Matsubara, M. Nagamachi, Hybrid *Kansei* Engineering System and Design Support. International J. of Industrial Ergonomics. 19 (2), 1997, 81-92.
[8] M. Nagamachi, *Kansei Engineering: Kansei / Affective Engineering* (*Industrial Innovation*). *CRC Press, 2010.*
[9] W. Jedlicka, Packaging Sustainability Tools, Systems and Strategies for Innovative Package Design. USA, John Wiley and sons, 2009.
[10] G. Calver, What Is Packaging Design, Roto Vision SA, 2004.
[11] C. Barnes, C. Southe, B. Henson, The Impact of Affective Design of Product Packaging Upon Consumer Purchase Decisions, DPP1 03: ACM 1-58113-652, 2003.
[12] H. Qing, Z. Kai, M.R. Chen, Packaging Design Research and Analysis Based on Graphic Visual. IPCSIT. Singapore. 28, 2012.
[13] K.C. Wang , S.M. Chen , "Product Form Design Using Anfis-KEModel." IEEE, 2007.
U.R. Orth, Malkewitz, Packaging Design Research and Analysis Based on Graphic Visual. International wine business research Monplier.